

Applicant: Axel ENDRISS
Docket No. R.305543
Preliminary Amdt.

AMENDMENTS TO THE SPECIFICATION:

Page 1, please add the following new paragraphs before paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 USC 371 application of PCT/DE 2004/001742 filed on August 4, 2004.

[0000.6] BACKGROUND OF THE INVENTION

Please replace paragraph [0001] with the following amended paragraph:

[0001] ~~Prior Art~~ **Field of the Invention**

Please replace paragraph [0002] with the following amended paragraph:

[0002] The invention relates to [[a]] an improved piezoelectric actuator, for instance for actuating a mechanical component, and to a sensor mechanically coupled with the piezoelectric actuator[[,]] ~~as generically defined by the preamble to the main claim.~~

Please add the following new paragraph after paragraph [0002]:

[0002.5] Description of the Prior Art

Please replace paragraph [0003] with the following amended paragraph:

[0003] It is widely known that by using what is known as the piezoelectric effect, a piezoelectric element can be constructed from a material having a suitable crystal structure. If an external electrical voltage is applied to these piezoelectric and electrostrictive ceramics, a mechanical reaction of the piezoelectric element ensues, which as a function of the crystal structure and of the regions to which the electrical voltage is applied ~~represents~~ produces a pressure or tension in a predetermined direction.

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Please replace paragraph [0004] with the following amended paragraph:

[0004] Because of the extremely fast and precisely regulatable stroke effect, such piezoelectric actuators can be used to make final control elements, for instance for driving switching valves in fuel injection systems in motor vehicles. The voltage- or charge-controlled deflection of [[this]] the piezoelectric actuator is utilized to position a control valve, which in turn regulates the stroke of a nozzle needle.

Please replace paragraph [0005] with the following amended paragraph:

[0005] Since the required electrical field intensities for actuating the piezoelectric actuator are in the range of several kV/mm, and as a rule only moderate electrical voltages are wanted for triggering, the construction of [[this]] the piezoelectric actuator in multiple layers of metallized piezoelectric ceramics stacked on one another produces a so-called multilayer actuator. To that end, there are inner electrodes between each of the layers, the inner electrodes being applied for instance by a printing process, and there are also outer electrodes by way of which the electrical voltage is applied. One typical method for producing such layers is sheet extrusion. The individual layers are metallized for producing the inner electrodes and are stacked on one another; the piezoelectric effect then develops between two layers having inner electrodes of different polarity.

Page 2, please replace paragraph [0007] with the following amended paragraph:

[0007] One such arrangement is described in German Patent Disclosure DE 199 60 971 A1, for example. The voltage signal that can be picked up, when used [[is,]] as a pressure sensor, is proportional to the force exerted or, as a travel sensor, proportional to the incident

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deformation. To adjust the change in length of a piezoelectric actuator in a regulated way, this change must be detected, which until now has required a separate component as the sensor element. For that purpose, a strain gauge, for instance glued to the piezoelectric actuator, or an inductive travel pickup, or as described in the prior art cited above, a further piezoelectric sensor may be employed.

Page 3, please replace paragraph [0008] with the following amended paragraph:

[0008] Advantages of the Invention

SUMMARY AND ADVANTAGES OF THE INVENTION

Please replace paragraph [0009] with the following amended paragraph:

[0009] The known piezoelectric actuator described at the outset is constructed, as noted, with a multilayer construction of piezoelectric layers and, in a piezoelectrically active region, with inner electrodes located between the layers, and is provided with contacting in alternation, from one layer to another, of the inner electrodes, for subjection to an electrical voltage. For forming a sensor part, further piezoelectric layers are present, with inner electrodes at which an electrical sensor signal proportional to the actuation of the piezoelectric actuator can be picked up via further outer electrodes. According to the invention, the piezoelectric layers for the actuator part and the piezoelectric layers for the at least one sensor part are advantageously integrated in one component in such a way that individual piezoelectric layers for the sensor part are located at predetermined spacings between the piezoelectric layers for the actuator part.

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Page 6, please replace paragraph [0021] with the following amended paragraph:

[0021] Drawing **BRIEF DESCRIPTION OF THE DRAWINGS**

Please replace paragraph [0022] with the following amended paragraph:

[0022] Advantageous exemplary embodiments of a piezoelectric actuator of the invention, with integrated sensors, are described **herein below**, in conjunction with the drawing, **in which: [.]** Shown are:

Please replace paragraph [0023] with the following amended paragraph:

[0023] Fig. 1, **is** a section through a piezoelectric actuator having a multilayer construction of layers of piezoelectric ceramic and inner electrodes between them, for both an actuator part and a sensor part;

Page 7, please replace paragraph [0024] with the following amended paragraph:

[0024] Fig. 2, **is** a section corresponding to Fig. 1, but in which the piezoelectric actuator is subdivided into a plurality of active actuator parts and passive sensor parts;

Please replace paragraph [0029] with the following amended paragraph:

[0029] Fig. 8 and Fig. 9, a further variant of the exemplary embodiment of Figs. 6 and 7; **and**

Page 8, please replace paragraph [0031] with the following amended paragraph:

[0031] **Description of the Exemplary Embodiments**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

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Please replace paragraph [0032] with the following amended paragraph:

[0032] In Fig. 1, a piezoelectric actuator 1 is shown, which is constructed in a manner known per se of piezoelectric layers of a ceramic material, such as so-called green sheets, having a suitable crystal structure, so that by utilizing the so-called piezoelectric effect when an external ~~electrical~~ direct voltage is applied to inner electrodes 2 and 3, via outer electrodes 4 and 5 not shown here but visible in Fig. 3, a mechanical reaction of the piezoelectric actuator 1 in the action direction 6 or 7, as applicable, takes place. The piezoelectric layers with the inner electrodes 2 and 3 are distributed here over the entire construction of the piezoelectric actuator 1 in the action direction 6 or 7 as applicable and are baked together in a manner known from the prior art, such as by sintering.

Page 10, please replace paragraph [0039] with the following amended paragraph:

[0039] In Fig. 10 and in associated Fig. 11, an exemplary embodiment is shown with which a further advantageous combination of the actuator part and sensor part is made possible, in which the inner electrode design is modified in such a way that in each piezoelectric layer, there is one actuator piezoelectric layer and one or more sensor piezoelectric layers. The smaller capacitor area 17, 18 or 19, 20, of the sensor inner electrodes of Figs. 10 and 11 is opposed by a larger number of sensor piezoelectric layers, and as a result, an acceptable sensor output signal can be attained here as well. In this variant, it is especially advantageous that a failure of a few individual layers, for instance from partial detachment of the external contacting means, has only a slight impact. Especially if there is a double embodiment of the sensor part, this variant has increased **safety reliability**.

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Page 11, please add the following new paragraph after paragraph [0039]:

[0040] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.